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# The Performance of Advanced Solar Cells for Interplanetary Missions

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Recent advances in space cell technology have produced substantial increases in Air Mass zero efficiency. Since these cells have been developed primarily for Earth orbiting missions, little is known of their behavior at distances far from the sun. Planned and potential missions in the coming years are expected to require operation out to the orbit of Jupiter. In addition, the potential for use of ion propulsion to reduce mission costs and spacecraft travel times, will lead to the need for arrays with very high power levels (10 - 20 kW) in the initial phases of the mission.

In order to better define the photovoltaic performance of arrays for these missions, JPL began an effort to measure advanced cell performance under a variety of LILT conditions. JPL is presently measuring the performance of these cells (high efficiency silicon, single and multi-junction III-V devices) under low intensity and low temperature (LILT) conditions corresponding to potential applications up to 5 AU from the sun. For these efforts, high efficiency silicon cells have been obtained from ASE, Sharp, and Sunpower and advanced III-V devices from Emcore, Spectrolab, and Tecstar. Testing has been done at JPL, GRC, and Spectrolab. In most cases, more than one test facility was used to test each manufacturer's cells, with the exception of Spectrolab, who did not test cells from any other manufacturer. The tests were conducted at multiple facilities in order to determine any measurement differences due to the test facility. In general, data from all facilities was found to be consistent.

It is well known that the temperature coefficient of voltage is much higher for silicon than the III-

V devices, so it was expected that the large efficiency difference between silicon cells and III-V cells at Earth would be reduced as the operating temperature decreased. The test results show that indeed, the multi junction cells do provide higher efficiency than silicon under the most severe LILT conditions. However, the advantage is rather modest, due to LILT induced losses in the III-V devices. This can be seen in figure 1, where efficiency is shown for a high efficiency silicon cell and in figure 2 , where efficiency is shown for a triple junction cell. While the silicon efficiency continues to strongly increase down to -160C, the triple junction cell efficiency tends to flatten at temperatures below -100C. The primary cell parameter affecting this is the fill factor, since the voltage temperature coefficient remains nearly constant. Consequently, silicon becomes more competitive as the solar distance is increased. For these conditions, device characteristics such as mass and radiation resistance can provide the justification for cell selection.

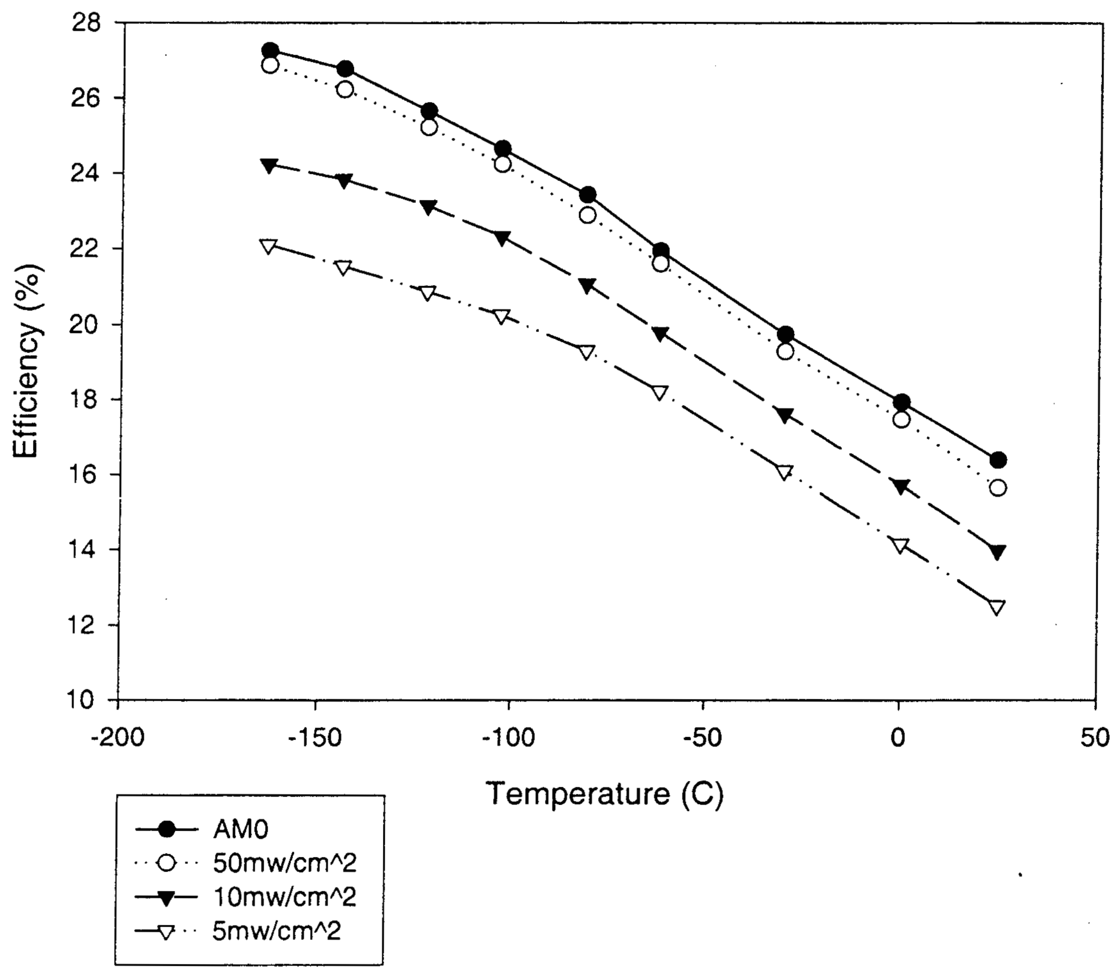


Figure 1. High Efficiency Silicon Cell Efficiency vs. Temperature and Intensity

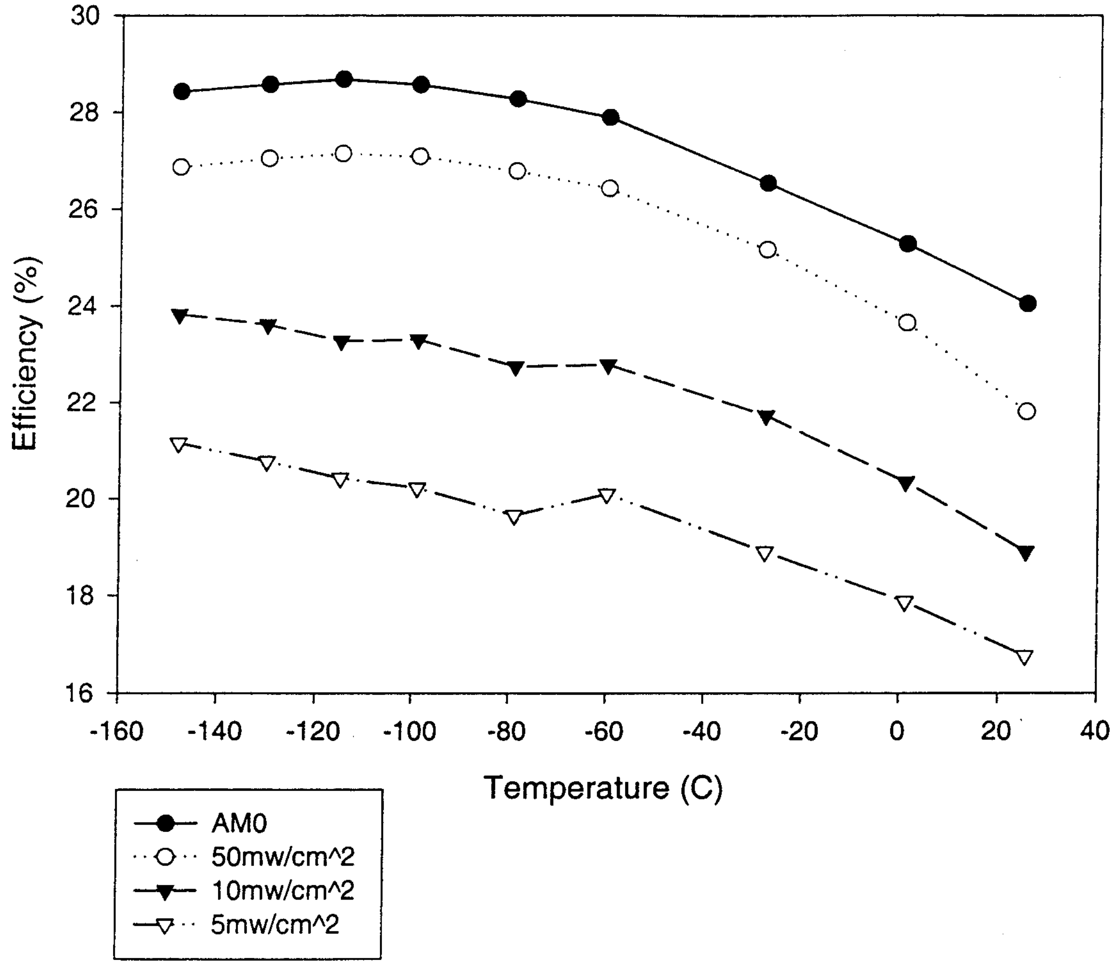


Figure 2. Triple Junction Cell Efficiency vs. Temperature and Intensity

The detailed results of this work will not only be used to help plan future Interplanetary missions, but will also be available to the manufacturers where it is hoped that the data will enable the implementation of device changes leading to improved device performance under LILT conditions. In particular, it is clear that multi junction devices do not presently provide the benefits under LILT conditions that have lead to their wide-spread use for Earth orbiting applications.

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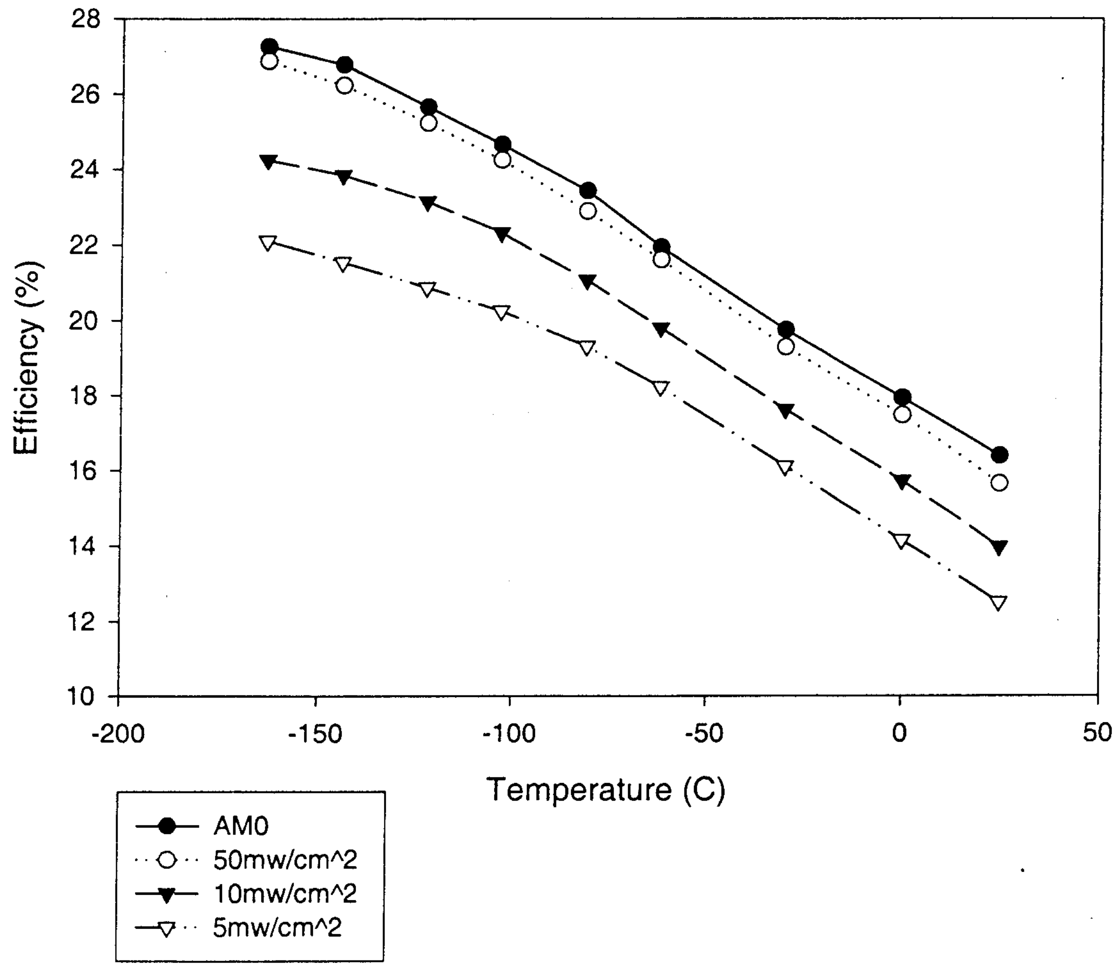


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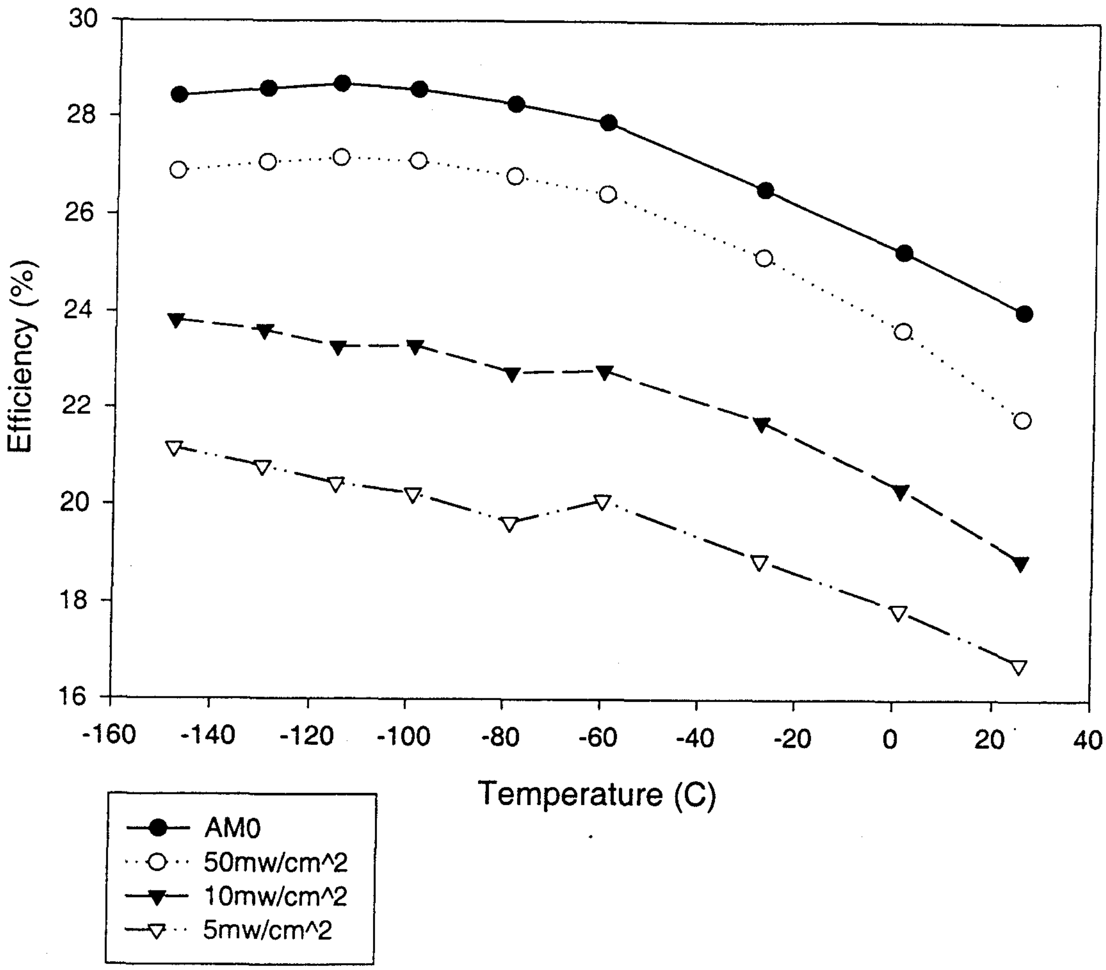


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